Wisconsin Geological
and Natural History Survey

I. C. 6353

SEPTEMBER, 1930

DEPARTMENT OF COMMERCE

UNITED STATES BUREAU OF MINES
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INFORMATION CIRCULAR

MILLING PRACTICE AT THE WHITE BIRD CONCENTRATOR, CANAM METALS CORPORATION, PICHER, OKLA.

BY

E. H. CRABTREE, JR.

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MILLING PRACTICE AT THE WHITE BIRD CONCENTRATOR, CANAM METALS CORPORATION, PICHER, OKLA. [1]

By E. H. Crabtree, Jr. [2]

INTRODUCTION

This paper, describing the milling practices at the White Bird concentrator, Picher, Okla., is one of a series on milling practices being published by the Bureau of Mines.

The concentrator of the White Bird mine, Canam Metals Corporation, is located in almost the geographical center of the present Picher mining camp in the Tri-State district, one-half mile east of the town of Picher, 1 mile south of the Kansas State line, and about 18 miles west of the Missouri State line.

The mining lease contains 200 acres, with the mill situated approximately in the center of the lease. Ore is mined at a depth of 275 ft. by open stope system with pillar support. It is hoisted to the surface through the mill shaft, located at the mill, and dumped directly into the mill hopper, and through two field shafts from which it is trammed in 2 1/2- ton cars by gasoline locomotive to the mill, and then hoisted up an incline to the mill hopper.

The topography of the country is practically level, necessitating elevating of material between consecutive milling operations. The flowsheet is typical of Tri-State concentrators, comprised of jigs, tables, and flotation equipment. Maximum capacity is 40 tons per hour.

Water for milling purposes is obtained directly from a small creek running by the plant. Two thousand gallons per minute are required.

Both electric and gas engine power are used in operations. Electric power is purchased from the Empire District Electric Co.'s steam plant at Riverton, Kans., 12 miles distant; natural gas piped from Oklahoma and Texas fields is purchased locally from the Consumers Gas Co.

The average mill load is 400 hp. Two 165 hp. Bessemer gas engines are employed. Motors are 220-volt, 3-phase, 25-cycle.

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U.S. Bureau of Mines Information Circular 6353".

[2] One of the consulting engineers, U. S. Bureau of Mines and Mill Superintendent of Canam Metals Corporation.

ORE TREATED

The ore occurs disseminated through a jasperoid breccia and filling the interstices between blue and white chert bowlders. The commercial minerals are sphalerite and galena. The gangue minerals are blue, white, and gray chert, jasperoid, calcite, dolomite, and small amounts of marcasite. The chert occurs principally as bowlders cemented by jasperoid or calcite with sphalerite. The dolomite is of two varities, the crystalline pink dolomite filling fractures in the chert and the massive, coarsely crystalline gray dolomite occuring as massive bowlders near the edges of the ore body. Considerable resistance to crushing is offered by the ore.

Galena is easily freed. Sphalerite, in most instances, is entirely free at 48-mesh size. Size of mill feed varies from slime to slabs which will pass a 6 inch grizzly located in the mill hopper. Moisture content is just sufficiently high to prevent excessive dust underground.

HISTORY OF CONCENTRATOR OPERATIONS

The mill was constructed in 1918 and consisted only of the jig and table departments. Since that time steady improvements have been made in operation. In 1924 the flotation department was added, enabling treatment of slimes produced both in mining and crushing operations, and in 1926 a 6 foot by 36 inch Hardinge ball mill was added, enabling treatment of the particles of gangue containing locked particles of mineral, locally termed "chats". In 1927 and 1928, larger rougher jigs and more efficient preliminary desliming devices were constructed, increasing the capacity of the mill from 30 tons per hour to 40 tons per hour and permitting better extraction to be made.

These changes have resulted in no marked decrease in milling costs but a very marked increase in metallurgical efficiency. The average zinc content of all tailings produced previous to 1927 was 1.95; the average zinc content of tailings produced during August, September, and October, 1929, was 1.08 percent.

The average zinc content of concentrates produced during the last few years is as follows, in per cent.

Year	Coarse zinc concentrates			Flotation zinc concentrates		
	Zn	Fe	Pb	Zn	Fe	Pb
1925	57.50	1.26	0.04	57.30	1.20	
1926	57.70	1.35	.05	55.50	1.36	
1927	57.00	1.45	.09	57.00	1.30	
1929 (Aug., Sept., Oct.)	59.80	1.47	.07	61.50	1.50	0.36

PRESENT METHOD OF CONCENTRATING

The concentrator is divided into three departments, jigging, tabling, and flotation. Figure 1 presents a flow sheet of the entire plant and the relationship of these departments.

The mine operates one 8-hour shift per day, while the concentrator operates 10 hours per day. As an average 312 tons are treated per 10-hour shift. All ore as it comes from the mine is dumped upon a 6-inch grizzly at the top of the mill hopper, through which it is broken by hand. Some hand sorting of the grizzly oversize was formerly practiced, but has now practically been discontinued.

All undersize of the grizzly passes into a 200-ton hopper, from which it is discharged through a gate to a 24-inch belt-driven jaw crusher. Considerable water is added at this point. Crusher product is practically all minus 3-inch in size and passes directly to a set of 42-inch-diameter Cornish-type geared rolls. These rolls are belt driven, as in all mill equipment, from a main-line shaft, and operate at a speed of 15 r.p.m.

Discharge of these breaker rolls is divided in two parts and elevated to two 4 feet by 8 feet by 1/2 inch round-hole, punchedplate trommel screens, each operating in closed circuit with a set of 36-inch Cornish-type rolls.

Undersize of each screen is deslimed in a 48-inch by 52-inch by 60-inch DeMier cone from which the slime passes back to the table feed dewatering drag. The coarse discharge of each cone constitutes the rougher jig feed.

Two rougher jigs operate in parallel. These jigs are of the Harz type, each containing six 42-inch by 48-inch cells, and operate at a speed of 95 r.p.m. Sieve cloths are 3/16-inch mesh. Chatters are of the horizontal-pipe type, with water introduced at one end and holes of 3/4 inch in diameter.

Rougher jigs discharge three products: Hutch product, chat product, and tailings. Hutch product is all minus 3/16 inch in size and passes directly to the cleaner jig. Chat product consists of locked mineral particles drawn by means of the chatters from the jig beds. The plus 3/16-inch free mineral is drawn at intervals through the sieves through holes provided with iron pins as stoppers until the bed is lowered to the desired depth, and thus becomes part of the Hutch product. Rougher jig tailings are deslimed in 48-inch by 52-inch by 60-inch DeMier cones, the discharge passing to waste and the overflow joining the overflow of the head cones in the table-feed dewatering drag.

The rougher operation is one of the most important in the flow sheet. Here 75 per cent of the mill tonnage is discarded as waste tailings; 10 percent of the tonnage, containing the free mineral at minus ½-inch size, is sent to the cleaner jig for final cleaning; 10 per cent of the tonnage, containing the locked mineral particles at minus 1/2-inch size, is sent to rolls for further grinding; and the slime produced in mining and primary crushing operations is sent to the table feed drag for classification previous to flotation.

The cleaner jig, also of the Harz type, contains six 36-inch by 42-inch cells and has a speed of 160 r.p.m. Sieve cloths are 1/8-inch slotted sheets. From the first hutch clean lead concentrates are produced, assaying 74 per cent Pb. Attempts are made to draw all marcasite possible with the lead concentrates. The second hutch discharge contains a middling product of sphalerite, galena and marcasite, and is returned to the head of the jig; thus a circulating load of this product is maintained, enabling a closer separation of the economic minerals to be made. From the last four hutchs clean zinc concentrates are made, assaying 59.9 per cent Zn, 0.07 per cent Pb, and 1.47 per cent Fe.

Dewatered cleaner jig tails are joined with the rougher chat product and elevated to a 4-foot by 8-foot by 1/8-inch round-hole, punched-plate trommel screen operating in closed circuit with a set of 36-inch Cornish-type rolls. Undersize from this screen is deslimed and passes to a 5-cell sand jig. Each cell has dimensions of 30-by 42 inches and is provided with 1/8-inch sieve cloth. Hutch product from the first cell, containing any lead or iron produced in the regrinding, passes back to the head of the cleaner jig. Clean zinc concentrates are drawn from the second and third hutches. Product from the last two hutches is returned to the cleaner jig. Sand jig tails are combined with the slime from the head of the jig and constitute the main feed for the table room from the table-feed drag.

TABLE DEPARTMENT

The table-feed drag is of the belt type, constructed of 20-inch elevator belt provided with sheet-iron drag plates, set at a pitch of 5 inches to the foot and traveling at the rate of 40 feet per minute. Overflow of this drag constitutes thickener feed for flotation. Sand discharge is elevated to a 4-foot by 8-foot 2-mm. punched-plate trommel screen. Undersize of this screen is classified in a series of hydraulic classifiers for individual table feeds. Seven Butchart concentrating tables produce clean zinc concentrates, lead-zinc middlings which are pumped to a separate table for recleaning, a zinc-gangue middlings product which is returned to the head of the table circuit, and tailings. Tailings from the first three tables, containing fine chats, are combined with the table-screen oversize, dewatered, and passed to a 6-foot by 36-inch Hardinge ball mill operating at a speed of 24 r.p.m. The ball-mill discharge returns to the head of the table circuit. Tailings from the last four tables are deslimed and discarded.

FLOTATION DEPARTMENT

Formerly, sufficient lead was contained in the flotation feed to demand differential flotation. The lead content of the mill feed in recent months, however, has decreased to where it is no longer economical to attempt separation of the zinc and lead minerals in the flotation circuit. Zinc concentrates only, are now being produced, containing what little lead is present in the feed.

Flotation equipment consists of a Butchart 50-foot Dorr-type thickener, three Butchart horizontal agitator-type flotation machines, accessory elevators and pumps, and a 3-disk, 6-foot American continuous vacuum filter.

Thickener discharge is elevated to the first machine, where pine oil, potassium xanthate, and copper sulphate are added. The three machines are in series. Concentrates froth is drawn off the first machine and part of the second machine, according to the quality of the feed, and passed to the filter. Froth from the remaining portion of the second machine and from the third machine is returned to the feed elevator. Tails from the third machine are discarded as waste. Average assay of flotation concentrates is 61.50 per cent Zn, 0.36 per dent Pb, and 1.07 per cent Fe.

BREAKING

Primary breaking is done in a 24-inch jaw crusher manufactured locally by the Webb City Foundry. Jaws, cushion plates, and side plates are made of cast iron, also manufactured locally by the same company. Capacity of this breaker is 40 tons per hour of minus 6-inch feed.

INTERMEDIATE CRUSHING

All intermediate crushing is done by geared rolls of the Cornish type. These rolls are 36 inches and 42 inches in diameter. Shells areof cast iron manufactured locally and are held to the cones by shingles. Only one shell is driven, the two shells being held together by tension springs.

FINE GRINDING

One 6-feet by 36-inch Hardinge ball mill is employed to grind sludge-mill screen oversize and tailings from the first three tables. This feed amounts to 10 tons per hour. Feed is minus 1/8 inch. Discharge is 46 percent minus 50-mesh. Pulp density is maintained at 70 per cent solids. Three-inch forged-steel balls are used, of the following composition:

	Per cent	
Carbon	0.70	Minimum
Manganese	.60	Minimum
Silicon	.20	Minimum
Phosphorus	.06	Maximum
Sulphur	.06	Maximum

The mill contains 8 tons of balls. Titanite steel liners are used. Steel consumption amounts to 2 pounds of balls per ton ore ground and 1 pound of liners per ton of ore ground. Drive is by a spur gear and pinion; the counter shaft is belt driven from the mill line shaft.

CONVEYING

All conveying is done by belt elevators. These range in width from 12 to 24 inches. Cups are spaced at intervals of 18 inches. All the larger elevators operate at a speed of 300 feet per minute. Drives are by a spur gear and pinion, the countershaft being belt driven off the line shaft.

Launders range in width from 6 to 18 inches and in slope from 1/4 inch to 2 inches to the foot. All launders are lined with cast-iron liners.

DEWATERING AND HANDLING OF CONCENTRATES

Jig concentrates are drawn off into the jig sluice boxes, where they are allowed to drain and are then shoveled into cars and transported to the mill storage bins. Table concentrates are discharged into catch boxes, from which they are also shoveled into cars. The moisture content of the combined jig and table concentrates is about 4 percent.

Flotation concentrates are dried in a 6-foot3- disk American continuous-type vacuum filter. No prethickening is required. Vacuum is maintained at 25 inches. Average moisture content of concentrate discharged is 10.5 per cent. Material from filter is discharged into a 1000-pound car in which it is transported to the mill storage bin.

All concentrates are sold in the bin to the smelters who load and transport it to the railroad cars.

DEWATERING AND DISPOSAL OF TAILINGS

All jig tailings are elevated and discarded in a heap. Fifty-foot elevators are used, thematerial being allowed to stack as high as possible and then distributed to the edges of the pile through 11-inch sheet-steel spouting. When all available room has been filled, another elevator is constructed on top of the pile and the procedure repeated. Surrounding the pile is an earth dam for retention of the water drained from the tailings, which is reused for milling purposes.

Table tails and flotation tails are pumped to a retention pond, where the material is stacked in piles. The water drains from the material and is reused for milling purposes. In general, no difficulty is encountered in the breaking of dams, or in stream pollution.

SAMPLING

Determination of weight of mill feed is made from the number of cans hoisted into the hopper. These cans are of a standard size and are calculated to hold 1180 pounds each.

All mill samples are taken by hand at intervals of one hour and picked up for assay each week. Head samples are taken from the undersize of the $\frac{1}{2}$-inch screens at the head of the rougher jigs. Individual unit assays are taken in the same manner. Assays of concentrates are taken from the mill cars by means of a sample gun. These assays are used for control work and as a check against the shipments of concentrates samples of the composite coarse tailings are taken on the tailings pile. Assays of the latter are combined with the assays of the fine tailings according to tonnage to give the assay of the entire mill composite tailings. This figure, with the assay of mill heads and assay of total concentrates, is used to calculate mineral extraction. As a check against this figure the extraction is also calculated from the amount of mineral produced and amount of mineral included in the mill heads. These two extraction figures normally check within 2 per cent.

WATER SUPPLY

Water supply is ample except during abnormally dry periods. No impurities detrimental to flotation exist during normal times, and hence no purification is necessary. In periods immediately following heavy rains, however, considerable difficulty is experienced, doubtless due to organic materials washed into the creek by the rain. At these times lime is used, but its benefit is doubtful.

Water is supplied to the jig mill and crushing department by an 8-inch Aurora single-stage centrifugal pump, belt driven by a 30-hp. motor, furnishing approximately 1500 gallons per minute. A 3-inch American single-stage pump supplies water to the table and flotation departments.

TABLE 1. - SCREEN SIZES

Mesh	Rougher heads	Rougher tails	Rougher chats	Cleaner heads	Cleaner tails	Sand-jig heads	Sand-jig tails	Table heads	Ball-mill discharge
Plus 3	14.9	24.1	61.0						
4	18.1	28.9	29.3	2.4	4.2				
8	24.6	30.0	8.0	8.6	13.6	1.2	1.1		
14	19.1	13.7	.9	21.0	24.8	48.8	39.2	0.2	1.7
28	11.4	2.6	.3	26.4	26.2	28.6	32.2	3.4	11.2
48	6.7	.3	.2	29.6	23.6	15.9	20.3	45.5	40.4
100	3.1	.2	.1	11.0	6.8	4.5	5.8	38.1	28.8
-100	2.1	.2	.2	1.0	0.8	1.0	1.4	12.8	17.9

TABLE 2. - Average Mill Assays, per cent

White Bird Concentrator Aug., Sept., Oct., 1929

	Zn	Pb	Fe
Mill heads	8.99		
Composite tails	1.08		
Rougher jig heads	8.50		
Rougher jig tails	1.24		
Table heads	10.50		
Table tails	1.32		
Coarse zinc concentrates	61.50	0.36	1.07
Coarse lead concentrates	5.20	74.00	1.07
Flotation heads	9.40		
Flotation tails	.60		
Flotation zinc concentrates	59.80	0.07	1.47

TABLE 3.- Metallurgical Data
August, September, and October, 1929

Total tons ore treated	24,974
Days operated	80
Hours operated per day	10
Ave. tonnage per 10 hours	312.18
Total tons concentrates	2241.00
Total average tons concentrates per 10 hours	28.01
Total tons lead concentrates	49.00
Average tons lead concentrates per 10 hours	0.61
Total tons zinc concentrates	2192.00
Average tons zinc concdntrates jigs per 10 hours	27.40
Total tons lead concentrates jigs	49.00
Average tons lead concentrates jigs per 10 hours	0.61
Total tons zinc concentrates jigs--	958.00
Average tons zinc concentrates per 10 hours	11.98
Total tons zinc concentrates tables	558.00
Average tons zinc concentrates tables per 10 hours	6.98
Total tons zinc concentrates flotation	676.00
Average tons zinc concentrates flotation per 10 hours	8.40
Recovery of lead	84.30%
Recovery of zinc	85.60%
Per cent recovery by jigs	36.8% zinc; 85.6% lead.
Per cent recovery by tables	21.5% zinc
Per cent recovery by flotation	26.0% zinc

Net water consumption per ton ore 3,840 gallons.

TABLE 4. - Summary of Costs,
August, September, and October, 1929.

Crushing	Labor	Supplies	Power	Total
Crushing	$0.014	$0.049	$0.023	$0.086
Jigs	.052	.002	.010	.064
Tables	.039	.015	.005	.059
Flotation	.036	.039	.015	.090
Fine grinding	-	.054	.024	.078
Elevating	.014	.012	.039	.065
Water supply	-	.004	.033	.037
Miscellaneous	-	..007	-	.007
Assaying	-	.018	-	.018
Total	.155	.200	.149	.504

Cost per Kw.h. $0.0155

Table 5. - Summary of Costs-in Units of Labor, Power and Supplies
Period ~~Covered~~ August, September, and October, 1929

		Operation	Repairs	Total
A. LABOR (man-hours per ton)				
Crushing		$0.0321	$0.0053	$0.0374
Secondary grinding		.0160	.0027	.0187
Classifying, screening, and conveying		.0160	.0027	.0187
Concentration	Flotation	.0641	.0107	.0748
	Gravity	.1283	.0213	.1496
Dewatering and Handling concentrates		.0321	.0053	.0374
Tailings disposal		.0321	.0053	.0374
Power		.0321	.0053	.0374
TOTAL MAN-HOURS PER TON		.3528	.0556	.4114
Tons per man per 10 hour shift		28.34	170.6	24.3

B. POWER	Kw.h. per ton	Percent total power
Crushing	1.86	15.1
Elevating	3.26	26.4
Jigging	.79	6.4
Pumping	2.76	22.4
Tabling	.43	3.5
Fine grinding	2.01	16.3
Flotation	1.22	9.9
	12.33	100.0

C. REAGENTS

Pounds per ton treated in flotation plant

Copper sulphate	1.14
Potassium xanthate	.26
Pine oil	.08

LEGEND

1. Hutch product
2. Chat product
3. Rougher jig tailings
4. Sand and slime
5. Shipping zinc concentrates
6. Shipping lead concentrates
7. Table tails (to ball mill)
8. Table middlings
9. Table tails (to waste)
10. Table lead-zinc middlings
11. Flotation zinc concentrates
12. Flotation middling froth
13. Table and flotation tailings to waste pond
14. Rougher jig tailings to tailings pile

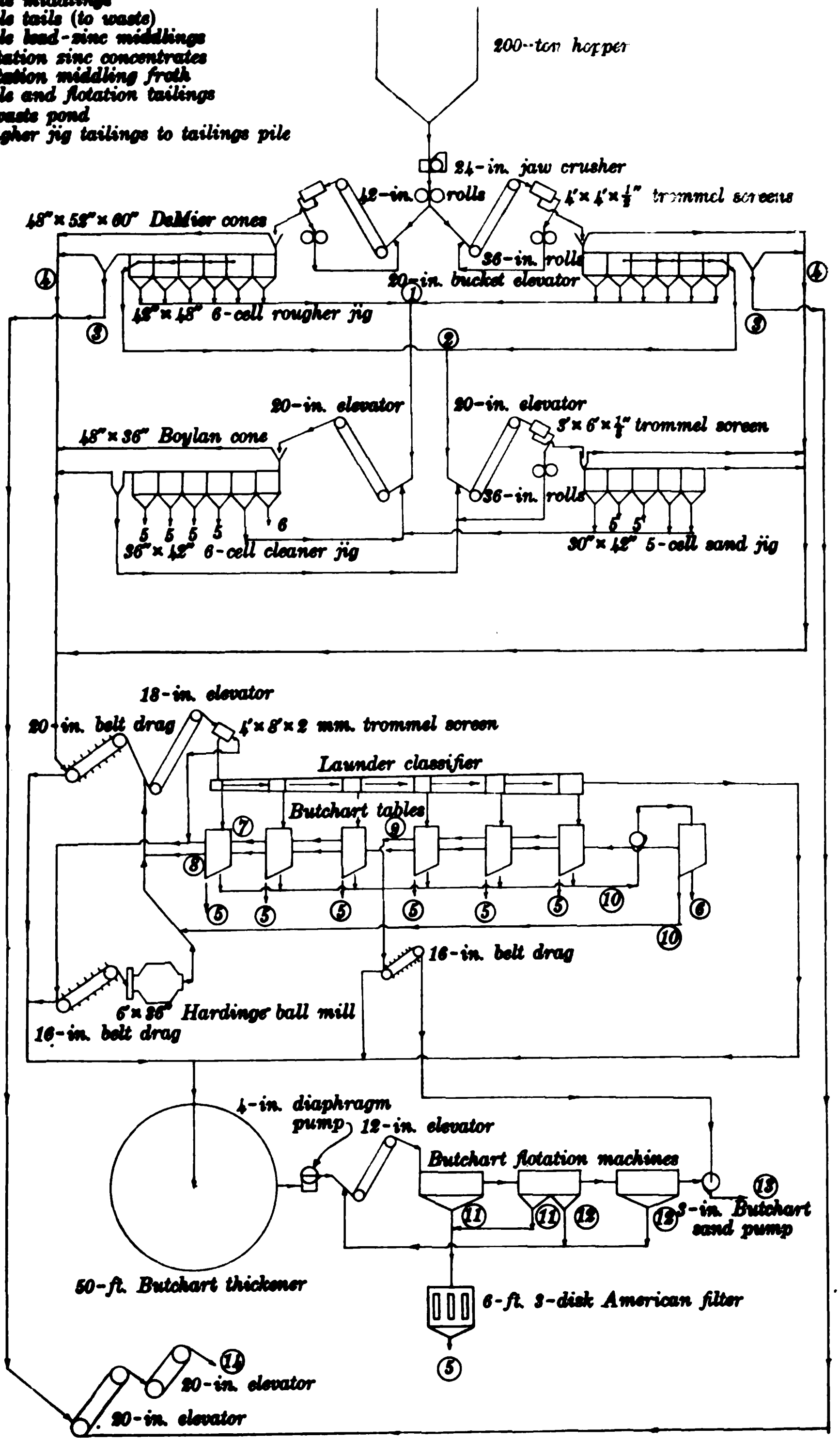

Figure 1. – Flow sheet of White Bird concentrator